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Title of Invention: Method of Making Plastic Tube and Mold Structure

3. Detailed Description of Invention
(Field of Invention)

The present invention relates to a method of making plastic tube and a mold structure.

(Prior Art)

A generally well known conventional method of making plastic tube comprises steps of placing a core (inner member) for forming a hollow portion of a tube inside a main mold for forming an outer portion of the tube, injecting a molten plastic material into a space between the surface of the core and the surface of the main mold, and opening the main mold and removing the core from the molded product after the molten plastic material has been hardened. According to such method, it is possible to relatively accurately and efficiently make a single piece tube extending in a straight line (i.e., a straight tube) having the diameter-to-length ratio of the tube lower than a certain value so that the core can be supported with sufficient strength.

However, it is generally impossible to apply such method for making a plastic tube bent in a certain shape (i.e., a curved tube), because it is difficult to remove the core from the molded product after injection molding. For this reason, it is known to make the mold in a dividable structure and divided parts are independently molded and then integrated by jointing the parts to one another. However, this method encounters problems such as requiring complicated injection molding steps in addition to the new jointing step after molding, thereby causing a disadvantage in maintaining accuracy of the finished product.

In order to alleviate such problems, it is known, as illustrated in Fig. 12, to obtain a curved plastic tube 55 by providing a pair of cores 52, 53 pivotally supported at their one ends to a main mold 51, abutting free ends of the cantilever supported cores 52, 53 to provide a combined core 54, injecting a molten plastic material in a molding cavity 50a between the surface of the combined core 54 and the molding surface of the main mold 51 and removing the cores 52, 53 by pivotal operation from the molded product 55 after the molten plastic material has been

hardened.

(Problems to be solved by the Invention)

However, the above method has a problem in that the supporting strength of the core 54 is not sufficient if the length-to-diameter ratio is larger than a certain value, thereby causing deformation or displacement of the core 54 due to injection pressure of the molten plastic material and resulting in defects such as deformation of the inner surface or uneven thickness of the tube 55.

The present invention is made in light of the abovementioned problems. It is an object of the present invention to provide a method of ensuring the supporting strength of the core and a mold structure therefore in case of integrally injection molding a plastic tube.

(Means to Solve the Problems)

In order to achieve this object, a first invention is a method of making a tube by abutting free ends of a pair of cantilever cores to combine them and injecting a molten plastic material into a molding cavity between the surface of the combined core and the molding surface of a main mold, comprising the steps of injecting the molten plastic material into the molding cavity in a condition where intermediate portions of the combined core is supported by supporting members extending from the molding surface of the main mold toward the core, subsequently retracting the supporting members to the molding surface of the main mold in the process of temperature decrease of the molten plastic material while applying appropriate pressure to the molten plastic material and subsequently removing the core after the time when temperature of the molten plastic material has been decreased to a predetermined level.

A second invention is a mold (or a molding tool) for molding a plastic tube comprising a pair of cantilever cores to be pivoted so that the free ends abut against each other to form a combined core and that a molten plastic material is injected into a molding cavity between the surface of the combined core and the molding surface of a main mold, characterized in further comprising supporting members for supporting intermediate portions of the combined core in such manner to be extended to or retracted from the inner member from the molding surface of the main mold.

(Advantages of the Invention)

According to the first invention, the molten plastic material is injected

in the condition when the intermediate portions of the combined core is supported by the supporting members, subsequently the supporting members are retracted and the molten plastic material is filled in space portions created by the retracted supporting members, thereby enabling to easily forming an integral curved tube while providing sufficient supporting strength to the core even for a large length-to-diameter ratio of the core. Accordingly, it is possible to prevent deformation or displacement of the core by the injection pressure of the molten plastic material.

On the other hand, according to the second invention, the supporting members are extended toward the core for supporting it at the time when the molten plastic material is injected into the molding cavity, while the supporting members are retracted after injection, thereby enabling to implement the above mentioned method of the first invention.

(Preferred Embodiments)

Now, preferred embodiments of the present invention will be described with reference to the accompanying drawings.

As shown in Figs. 8 and 9, the plastic tube 1 according to the present invention is integrally formed with mounting flanges 2f, 3f at both ends of the tube and comprises an upper half 2 and a lower half 3 which are curved along the center lines L2 and L3 with the radius of curvature R2 and R3, respectively. The upper half 2 and the lower half 3 are integrally injection molded.

As shown in Fig. 1, a molding tool 10 for molding the tube 1 comprises a main mold 11 having a molding surface 11a for forming the outer portion of the tube 1 and a core 14 for forming the hollow portion of the tube 1. The core 14 comprises a first core 12 for forming the hollow portion of the upper half 2 of the tube 1 and a second core 13 for forming the hollow portion of the second half 3.

The first and second cores 12 and 13 are provided with arm portions 12a and 13a, respectively. One ends of the arm portions 12a and 13a are pivotally supported onto the main mold 11 by way of hinged axes 12b and 13b, respectively. The cores 12 and 13 are set by pivotal movement so that the free ends of the cores 12 and 13 move into the main mold 11 and are combined together by abutting against each other, thereby forming a combined core 14 to form a molding cavity portion 10a between the surface of the combined core 14 and the molding surface 11a of

the main mold 11.

Then, a molten plastic material is injected into and filled the molding cavity portion 10a. When the temperature of the plastic material has been decreased to a certain level, the main mold 11 is opened and the first and second cores 12 and 13 are pivoted outwardly from the main mold 11, thereby providing the tube 1 of desired shape and size as shown in Figs. 8 and 9.

It is to be noted that the main mold 11 is a two-piece mold divided into two parts along a mold separation line Pl (see Fig. 9) and is configured to be moved in an open position or a closed position in the direction of the sheet of paper in Fig. 1. Although abbreviated in Fig. 1, the molding tool 10 is provided with upper and lower pushing molds for making the mounting flange portions 2f and 3f. In the condition that the combined core 14 is inserted into the main mold 11 and the pushing molds are mounted, it is configured that both upper and lower ends of the cores 12 and 13 are fixed. If (the cores 12 and 13 defining) the core 14 are identical to each other in shape and size, it is possible to largely decrease the maximum moment load working upon the fixed portions at the ends of the core 14 at the time of injection molding of the molten plastic material as compared to a mounting structure in which their one ends are fixed and the other ends are free, or their one ends are fixed and other ends are simply supported.

In this particular embodiment, there are provided support pins 15 - 15 at intermediate portions of the combined core 14, for example the abutting portions of the first core 12 and the second core 13 for stably supporting the core 14 against the injection pressure of the plastic material. As shown in Figs. 2 and 3, plural (for example 3) support pins 15 - 15 are disposed at an equal spacing along the circumference. As shown in a greater detail in Fig. 5, each of the support pins 15 - 15 is buried in the main mold 11. Each support pin 15 has a body portion 15b formed with a rack 15c to mesh with a pinion 16 that is driven in a forward/backward direction by an electrical motor 17. When the pinion 16 is made to rotate by the electrical motor 17, the support pin 15 is arranged to extend or retract between the molding surface 11a of the main mold and the core 14. The abutting portions of the core 14 are formed with pin receiving portions 14a for mating with end portions of the support pins 15 - 15. It is to be noted, however, that a driving mechanism comprising, for example, a hydraulic cylinder driven by a hydraulic pump, an electromagnetic valve or the like may be used instead of the driving mechanism comprising the rack 15c, the pinion 16 and the electrical motor 17. Concretely, although not shown, the electrical motor 17

is electrically connected to a control unit of a tube injection molding apparatus so that the support pins 15 - 15 are controllably driven to move forward or backward in response to the predetermined timing in synchronism with the open/close operation of the molding tool 10, the pivoting operation of the cores 12 and 13, or the injection timing of the molten plastic material.

Now, an operation of the support pins 15 - 15 will be described hereinafter.

The first core 12 and the second core 13 are combined together by abutting their free ends against each other and are set within the main mold 11 to define the combined core 14. The support pins 15 - 15 are moved toward the core 14 from the molding surface 11a of the main mold so that the end portion 15a of each support pin 15 extends into the molding cavity 10a and is mated with the respective pin receiving portion 14a of the core 14.

Then, under the above condition, the molten plastic material is injected into and filled in the molding cavity 10a (see Fig. 2). That is, if described with an example of nylon resin containing about 30wt% of glass fiber as a reinforcing filler, it is injected, for example as shown in Figs. 6 and 7, at a predetermined initial pressure (for example about 1000 kg/cm^2) and a predetermined injection temperature (for example about 300℃). At this time, the core 14 is prevented from moving in the radial direction by the support pins 15 - 15 so as to be stably supported against injection pressure of the molten plastic material.

Then, after completing the injection and filling, in the process of temperature decrease of the molten plastic of the molding mold 10 to the level near temperature Ta (for example the predetermined temperature Tp), the support pins 15 - 15 are retracted to flush with molding surface 11a of the main mold. At this time, the injected and filled molten plastic material in the molding cavity 10a is held at a secondary pressure (for example about 400kg/cm^2) lower than the initial pressure and the plastic material at the secondary pressure is filled with the spaces formed by the retraction of the support pins 15 - 15 (see Fig. 3).

The retracting operation of the support pins 15 - 15 is carried out at an appropriate timing when the molten plastic material is in the temperature range that its fluidity is maintained and is able to fill the spaces by the secondary pressure applied thereto. More preferably, a gate through which the molten

plastic material is injected into the molding cavity 10a is located as close to the locations for the support pins 15 - 15 so that the spaces are filled smoothly.

Subsequently, it is allowed that the temperature of the injected and filled plastic material goes down near the mold temperature Ta of the molding tool to harden the plastic material before the first core 12 and the second core 13 are pivoted outwardly from the main mold 11 for removing these cores 12 and 13 out of the molded product 1. Then, the molding tool 10 is opened up to obtain the tube 1 as shown in Figs. 8 and 9.

In this case, there are formed three projecting portions 1a on the inner surface of the tube 1 at the locations corresponding to the abutting portion of the cores due to the pin receiving portions 14a as shown in Fig. 4. On the other hand, there are formed, for example, three recessed portions 1b on the outer surface portion corresponding to the retracted locations of the support pins 15 - 15. These projecting portions 1a and the recessed portions 1b are specified in the tolerable range of size, depth, etc. depending on functions and applications required for the tube 1. It is to be noted, however, that the pin receiving portions 14a - 14a of the core 14 (i.e., the projections 1a - 1a on the inner surface of the tube 1) can be eliminated by forming the ends of the support pins 15 - 15 in a curvature corresponding to the surface configuration of the core 14 so that the ends of the support pins 15 - 15 abut against or push on the surface of the core 14 for supporting the core 14. In this case, the support pins 15 - 15 are not necessarily provided at the abutting portion of the first core 12 and the second core 13, rather they may be located at any locations of the combined core 14.

As described hereinabove, according to the embodiment of the present invention, since there are provided plural support pins 15 for supporting the combined core 14 at any halfway locations thereof in such a manner that the support pins 15 move toward or retract from the core 14 from the molding surface 11a of the main mold 11, the core 14 is supported by moving the support pins 15 - 15 toward the core 14 while the molten plastic material is injected into the molding cavity 10a. On the other hand, after completing the injection, the support pins 15 - 15 can be retracted to the location flush with the molding surface 11a of the main mold. And the spaces created by the retraction of the support pins 15 - 15 are filled with the molten plastic material, thereby enabling to easily integrally molding a curved tube by the use of the combined core 14. With sufficient supporting strength of the core 14, it is possible to prevent

deformation or displacement of the core 14 due to the injection pressure of the molten plastic material.

Although the above embodiment is directed to making the curved tube 1 curved along arced lines L2 – L3, it is to be noted that the present invention should not be restricted to such particular example and can effectively be applied to a tube 21 comprising a straight tube portion 22 and a curved tube portion 23 as shown in Fig. 10. That is, plural support pins 27 are provided for supporting a combined core 26 comprising a first core 24 and a second core 25 which abut against each other in such a manner that the support pins move toward or retract from, for example, the abutment portion of the core 26. Also, the present invention is effectively be applied to make a straight tube 31 having a large length with respect to the diameter of a core 32, for example as shown in Fig. 11. In this case, the ends of the support pins 33 – 33 is made in a curved shape corresponding to the surface shape of the core 32 and the support pins 33 – 33 may be located at any advantageous location along an single piece core 32.

4. Brief Description of the Drawings

Fig. 1 is a longitudinal cross section view of the molding tool and the tube according to an embodiment of the present invention;

Fig. 2 is a across section view along the line A – A in Fig. 1 when the support pins are moved forward;

Fig. 3 is a cross section view along the line A – A in Fig. 1 when the support pins are retracted;

Fig. 4 is a transversal cross section view of the tube along the line A – A in Fig. 1;

Fig. 5 is a magnified cross section view to show the driving mechanism for the support pin;

Fig. 6 is a graph to show the time change of the injection pressure of the plastic;

Fig. 7 is a graph to show the time change in temperature of the molded plastic material in the molding tool;

Fig. 8 is a front view of the tube according to the above embodiment of the present invention;

Fig. 9 is a plan view along the line B – B in Fig. 8;

Figs. 10 and 11 are longitudinal cross section views for molding tools and tubes according to other embodiments of the present invention; and

Fig. 12 is a longitudinal cross section view of a conventional molding tool and a tube made thereby.

In the reference numerals,

1, 21, 31	tube
10	molding tool
11	main mold
11a	molding surface of main mold
12, 24	first core
13, 25	second core
14, 26	combined core
15, 27, 33	support pins